

ELECTRONIC WARFARE (596)

Academic Program Information

(Revised October 2004)

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PREFACE

This booklet has been prepared primarily to provide incoming students with information about the academic program and advising procedures for the Electronic Warfare Systems Engineering Curriculum (#596).

Disclaimer --- Due care has been exercised to ensure that the information contained in this document is accurate at the time of writing. However, it is ultimately the student's responsibility to ensure that degree requirements are satisfied. These are specified in the Academic Policy Manual. Requirements beyond those specified in the Academic Policy Manual may be imposed by the Information Systems Department. At the present time, the Department has not imposed any such requirements. In all cases, the Chairman of the Department will have the final authority to recommend candidates for award of the degree.

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I. INTRODUCTION

Electronic Warfare (EW) Systems Engineering is an interdisciplinary graduate curriculum leading to the degree of Master of Science in Systems Engineering. This unique program was developed at NPS and began in March 1977. The original program of study focussed on the design and operation of traditional electronic systems used by the Navy in the radar, infrared, and communication frequency bands. Since that time the program has been split into two separate programs: Information Warfare (IW) and Electronic Warfare. The current EW program is basically the same as the original program, but it has been updated to include some IW and joint services topics. Both curricula are administered by the Department of Information Sciences.

The program consists of prescribed course work, a seminar program, field trips, and thesis work. The purpose of this booklet is to provide you with the basic information you will need about your program.

II. TYPICAL PROGRAM

The EW Systems Engineering program is designed to provide you with a broad education. It consists of courses in mathematics, physics, electrical and computer engineering, operations analysis, computer science, and meteorology. The breadth of this program is the feature which distinguishes it from the EW option in the ECE program, which is more technically oriented and leads to the MSEE degree. Entry requirements for the EW Systems Engineering program are a C⁺ average in previous college level work, completion of a calculus sequence with an average of C⁺ or better, and completion of a calculus based physics course with a grade of C or better.

A typical course matrix is shown in Table 1. The program is designed to provide students with educational skills in the critical areas of:

Subject Area	Core Courses
Electromagnetics	EO2652, EO3602, EO4612
IW/EW	EC3700, EC4690
Communication Systems	EO3512, EO4911
Operations Research	OS2103, OS3003, OS3604, OS4601
EO/IR	PH3204, PH4209
Computer Networks	CS3030, IS3502, CS3600
Meteorology	MR3416

The breadth of study is based on educational skill requirements determined by the U.S. Navy and, therefore, do not strictly apply to international students. However, your government has selected this curriculum based on a plan of study that includes these topics. If you have already had courses in any of the above areas and wish to eliminate them from your program, the validation process described in the next section can be used. Students can modify their programs to meet personal educational goals, but it is expected that **MODIFIED PROGRAMS SHOULD INCLUDE COURSES IN THE ABOVE AREAS.**

Modified programs must satisfy the degree requirements and be approved by your Academic Associate and Curricular Officer. Courses taken for degree credit are generally **limited to science, engineering, mathematics, physics, computer science, and operations research**. Note that international students are required to take IT1500 and IT1600 as soon as possible after arriving at NPS.

Table 1: Typical Program for International EW Students. Refresher courses can be tailored to suit an individual student's background (revised May 2004).

Ref (Su)	MA1114 (5-2) Single Variable Calculus & Matrix Algebra	Physics, math, engineering, or computer science refresher course	EC1010 (1-1) Matlab (none)	IT1600 (4-2) Communication Skills (none)
Q1 (F)	MA1115 (5-2) Multivariable Calculus (MA1114)	MA2121 (5-0) Differential Equations (MA1114)	PH2203 (4-0) Waves & Optics (MA1115)	IT1500 (3-0) American Life & Institutions (none)
Q2 (W)	OS2103 (4-1) Applied Probability (MA 1115)	MA3139 (4-0) Fourier Analysis & PDEs (MA1115 & MA2121)	EO2102 (4-2) Intro to Circuits & Power Sys (MA2121)	EO2652 (4-1) Fields, Waves & EM Eng (MA1115)
Q3 (Sp)	CS2971 (3-2) Intro to C++ Programming (none)	OS3003 (4-0) Operations Research for IW (OS2103)	EO3602 (4-2) Antennas & Propagation (EO2652)	EO2512 (4-0) Intro to Com & CM (none)
Q4 (Su)	EO3512 (4-0) Communication Engineering (EO2512)	Approved Elective	EO4612 (4-2) Microwave Devices & Radar (EO3602)	CS3030 (4-0) Comp Arch & Operating Sys (CS2971)
Q5 (F)	EO4911 (2-0) Communications & Countermeasures (EO3512)	EC3700 (3-2) Joint Services EW (EO2652 & OS2103)	OS3604 (4-0) Decision & Data Analysis (OS2103)	CS3600 (4-2) Computer Security (CS3030)
Q6 (W)	IW0810 (0-8) Thesis	IS3502 (3-2) Computer Networks (CS3030 & OS3003)	OS4603 (4-0) Test and Evaluation (OS3604)	MR3419 (4-0) Atmos. Factors for EM & EO (none)
Q7 (Sp)	IW0810 (0-8) Thesis	EC4690 (3-2) Radar Electronic Warfare (EO4612)	EC4010 (3-2) Principles of Systems Engineering (Four quarters)	PH3204 (3-2) Electro-Optics & CM (PH2203 & EO2652)
Q8 (Su)	IW0810 (0-8) Thesis	IW0810 (0-8) Thesis	Approved Elective	PH4209 (3-2) EO/IR Systems & CM (PH3204)

III. MODIFIED PROGRAMS

In most cases, your academic program can be modified to meet your specific educational goals. All scheduling and program modifications are done with a school-wide software program called PYTHON. Go to the NPS intranet home page (<http://intranet.nps.navy.mil>) and follow the link to PYTHON. The curriculum office will provide detailed instructions on how to add, drop, and move courses in PYTHON.

A. Validation of Courses

NPS has a formal process to verify that a student has knowledge of a course's subject matter, and therefore can omit the course from his program. It generally requires taking a comprehensive written or oral exam on the course material. Section 332, Validation of Courses, from the Academic Policy Manual appears below:

VALIDATION OF COURSES

1. A student with the appropriate background may validate a course that is required for his/her curriculum. Validation will allow the student to omit that course from the program of study. However, **no credit will be granted for a course that has been validated**. The basic purpose of course validation is to make optimal use of the student's time at the Naval Postgraduate School. Every validation must be justified by documented evidence of prior work in the area of the course to be validated.
2. The validation of a course must be approved in writing by the chairperson of the department offering the course or by someone designated in writing by the chairperson to act for him/her in this regard. Specific criteria for validation (e.g., review of the student's transcripts or examination on the material of the course) are left to the discretion of the cognizant department chairperson.
3. After validating one or more courses, it is appropriate for a student to complete his/her program in less than the maximum time allowed, to include additional elective courses in the program, and/or to devote additional time to thesis research with the concurrence of the thesis advisor.

IT IS NOT NECESSARY TO VALIDATE UNDERGRADUATE COURSES FOR THE EW PROGRAM. You can skip a 2000 level course that is a prerequisite for a higher level course if you have already taken a similar course. However, in the higher level course it will be assumed that you are familiar with all of the material in any of the prerequisite courses. Some departments will insist that you validate prerequisite courses to ensure that you do indeed meet the follow-on course requirements. If you are uncertain, talk to the course instructor and the Academic Associate to obtain their advice.

B. Electives and Elective Tracks

If you are able to customize your program you may want to consider selecting elective courses from various department offerings. Course substitutions must be approved by the Academic Associate. The modified program must still satisfy the degree requirements. Furthermore, modified programs should

maintain a balance of courses in the critical academic areas listed on page 2. Check the prerequisite structure in the NPS Catalog.

C. Course Matrix Worksheet

On the next page you will find a worksheet which you can use to set up a modified program for yourself. Keep in mind that all courses are not offered every quarter. Information on course offerings is available in Python and also published once each year. See your Academic Associate for the latest data. (Many departments post this information on the web, <http://intranet.nps.navy.mil>). Throughout the quarter, be aware of the deadlines for entering data into Python. After certain date Python is locked, and modification of your matrix for the next quarter will not be permitted until the first day of classes.

>>>>>>>>>> Warning on small course sizes and cancellations <<<<<<<<<<<<

It is important for all students to be aware that requests to drop a course at the start of a quarter CAN BE REFUSED if it will cause the course size to drop below 7. Courses with less than 7 students are in danger of being cancelled. It is not fair to the rest of the class to have a student back out and leave everyone else hanging.

Do not enroll for extra courses with the intent of dropping at the start of the quarter. The drop request may be refused and you will be stuck with a heavy load.

This policy is set by the Dean of Instruction, and is not something imposed by the EC or IS departments, or the 596 curriculum.

Ref				
Q1				
Q2				
Q3				
Q4				
Q5				
Q6				
Q7				
Q8				

IV. DEGREE REQUIREMENTS

A. System Engineering

The typical programs presented in Section III meet all requirements for the degree Master of Science in Systems Engineering. The requirements for the degree are specified in Section 222.20 of the NPS Academic Policy Manual as shown below. If your program is modified you will need to ensure that these degree requirements are satisfied. Use the checklist attached.

DEPARTMENTAL REQUIREMENTS FOR THE DEGREE
MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY
(COMMAND, CONTROL AND COMMUNICATIONS)
OR
(ANTISUBMARINE WARFARE)
OR
(SPACE SYSTEMS OPERATIONS)
OR
MASTER OF SCIENCE IN SYSTEMS ENGINEERING
(ELECTRONIC WARFARE)

1. The degree of Master of Science in Systems Technology/Engineering will be awarded at the completion of an inter-disciplinary program carried out in accordance with the following degree requirements:

- (a) A minimum of 45 quarter hours of graduate level work, of which at least 15 hours must represent courses at the 4000 level. Graduate courses in at least four different academic disciplines must be included and, in two disciplines, a course at the 4000 level must be included.
- (b) An approved sequence of at least three courses constituting advanced study in an area of specialization must be included.
- (c) In addition to the 45 hours of course credit, an acceptable group project or thesis must be completed.
- (d) The program must be approved by the chairperson of the appropriate academic group.

2. The thesis requirement for the Master's degree may be waived upon the approval of the chairperson of the appropriate academic group under the following circumstances:

- (a) The student has been admitted to an Engineer's degree or a Doctoral program.
- (b) The student has completed four 4000 level courses of a minimum of 12 credits over and above the course requirements for the Master's degree set forth in paragraph 1.
- (c) The Engineer's thesis or Doctoral dissertation topic selected has relevance to Systems Technology.

3. In the event that student completes more than one major, only the principal major will be identified on the diploma.

B. Degree Requirements

To ensure that your modified program meets degree requirements, you may wish to use the degree requirements checklist attached. When totaling your degree credits note that lecture hours count full value, but laboratory hours are only half of their value. For instance, a (4-1) course is 4.5 degree credits. If you have questions, discuss them with your Academic Associate.

LIST OF REQUIREMENTS FOR THE SYSTEMS ENGINEERING DEGREE

1. 45 hours minimum at 3000 and 4000 levels.
2. 15 hours minimum at the 4000 level.
3. Graduate courses in four different academic disciplines (e.g., MA, PH, EC/EO, OR/OS, MR, AA, etc.).
4. 4000 level course in two academic disciplines.
5. Approved sequence of three courses constituting advanced study in an area of specialization.
6. Thesis.

C. Final Check and Nomination for Degree

During the last quarter prior to graduation, normally the Summer Quarter, you must be nominated for award of the MSEE Degree. This is accomplished in a memo initiated from your Curriculum Officer and Academic Associate to the Academic Council. At this time, a final check will be made to verify that degree requirements have been met. The form for this purpose is attached at the end of this booklet. Forms are also available in the Curriculum Office or from your Academic Associate. At the beginning of your last quarter, obtain a copy of this form and fill in the required information. During the third or fourth week of the quarter, take this form and a copy of your transcript to your Academic Associate. Once the information has been verified and the form signed, return it to the Curriculum Office and you will be nominated for your degree. At this point, successful completion of your last quarter courses and your thesis is all that is required to receive your degree.

D. Dual Degree Program

A small minority of students follow dual degree programs. This is not encouraged since it generally requires both advanced preparation as well as course overloads and often results in difficult scheduling problems. Dual degree programs require the approval of the Academic Council (Special Programs Committee). Separate courses must be used to satisfy the requirements for each degree. The student must demonstrate and maintain academic performance near the top of his program or the dual degree

program will be terminated. Requirements are outlined in Section 341 of the NPS Academic Policy Manual which appears below.

DUAL DEGREE PROGRAMS

1. Any program which can lead to the award of two Master's Degrees is, in its entirety, a SPECIAL PROGRAM and it must be approved by the Academic Council.
2. A qualified student desiring admission in a dual degree program must apply at least one year prior to his/her graduation. The application must be approved by the chairperson(s) of the appropriate department(s) or academic group(s), the student's Academic Associates, and the Curricular Officers. The application must include a course matrix.
3. The Academic Council requires a written endorsement of the dual degree program from the student's sponsor or a written attestation by a department chairperson or a curricular officer that the sponsor has been notified of the student's proposal.
4. The program which leads to two graduate degrees must satisfy the requirements of both degrees. Course validations early in the program will allow the student to take the additional 3000 and 4000 level courses as required for the dual degree program. The dual degree program must satisfy the enrollment limitations listed under Section 420-5 (see below).
5.
 - a. A student is qualified to enter a dual degree program if the Curriculum Officer and Academic Associate certify that he/she is in the top 20% of the students in his/her curriculum.
 - b. The special dual degree program will be terminated if the student does not maintain a performance that places him/her within the top 50% of each program. The Curricular Officers and Academic Associates will monitor the student's performance each quarter and will report to the Academic Council if such performance is not being maintained.
6. Satisfactory progress in course and thesis work by the student in the dual degree program must be reported to the Academic Council no later than two quarters before the student's scheduled graduation.
 - a. At this time the student's thesis advisors must certify that the student has made substantial progress in his/her thesis.
 - b. A single thesis may satisfy the requirements of departments provided the thesis is co-advised by a member of each department.
 - c. If satisfactory progress is not maintained, the Academic Council will require that the student revert to his/her original single degree program.

If you intend to apply for approval of a dual degree program you must obtain approval of your curriculum sponsor and make application at least one year prior to your scheduled graduation date. Currently you must be among the top 20% of students in your curriculum to apply, however there are exemptions for programs with small enrollment. The requirements change from time to time, so check the Academic Policy Manual for the most recent requirements.

V. ENRICHMENT

A. Seminars

A seminar program is an integral part of the curricula. The seminars are intended to enrich your educational experience by providing exposure to topics presented from experts from outside NPS. There will be speakers from both industry and the Department of Defense. You should find that as your education progresses you get more and more out of the presentations.

B. Field Trips

A second component of the enrichment program is field trips. These will provide further information on special topics and areas on site. You will have an opportunity to meet and talk with people working in the field and in some cases see equipment. As you progress through your program, you will find that your ability to absorb what you see and hear and to interact with the people you meet will grow and you will gain confidence in your ability to apply what you have learned in the real world.

C. Conferences

Each year approximately 40 to 50 conferences and meetings are held on the NPS campus. Many of these are related to EW and will be of interest to you. Examples would include the Tri-Service Radar Symposium and the Joint Electronic Warfare Conference. Conferences held on the campus are open to students and faculty with the proper clearance, free of charge.

VI. THESIS

A thesis must be completed unless this requirement is waived by the Chairman of the EW Academic Group. The requirement would be waived only in exceptional circumstances. The major hurdle here is finding a thesis topic and an advisor. The best way to accomplish this is to talk to the faculty who do research in the areas of interest to you and find out what topics they currently have available. A partial table of faculty members involved in EW related research is shown in Table 2. An alternative, if you have selected a topic independently, is to find a faculty member willing to supervise it. This is more difficult. Most faculty members are fully committed to teaching, research, administration, and professional activities and it is difficult for them to find time to supervise a topic not directly related to funded research. See your Academic Associate for information on faculty members who supervise theses for EW students and their areas of interest.

Thesis time is normally scheduled during the last three quarters of the program (Winter/Spring/Summer). The objective is to start the work during the Winter, concentrate on it during the Spring, and then wrap up loose ends and write the thesis during the Summer. One should allow ample time for the thesis to be read by the advisor and second reader, approved by the Chairman, and processed through the Thesis Office prior to graduation.

It is never too early to begin thinking about your thesis. The sooner the thesis work is begun, the more satisfying the experience. Generally, a topic and advisor should be identified no later than the Fall Quarter of the second year. Once this has been accomplished, a thesis proposal should be prepared and submitted to the IW Academic Group for review and approval. This should be done prior to the end of the Fall Quarter. Forms are available in the Curriculum Office.

Table 2: Partial List of NPS Faculty Members with EW Related Research

<u>Faculty</u>	<u>Dept.</u>	<u>Office</u>	<u>Phone</u>	<u>Research Areas</u>
Adler	EC	S-219	2352	COMINT, propagation
Cooper	PH	S-212	2452	IR
Davidson	MR	O-229A	2309	Meteorology & propagation
Hutchins	EC	S-432	3289	Sensor fusion
Hughes	OR	R-203	2484	Operational/tactics analysis & simulation
Jenn	EC	S-414	2254	Radar, target ID, & RCS
Knorr	EC	S-428	2815	Radar, EW systems & devices
Lebaric	EC	S-464	2690	Electromagnetics & communications
Loomis	EC	S-446	3214	ELINT
Morgan	EC	S-410	2677	Radar, target ID, & RCS
Pace	EC	S-537	3286	Radar, ECM, ECCM, signal processing
Powers	EC	B-223	2679	Electro-optics
Schleher	EC	R-201E	3767	ECM, radar, operations/tactics
Titus	EC	B-204	2560	Radar, ECM, optics/acoustics
Wash	MR	R-249	2295	Remote sensing, EM propagation
Wadsworth	EC	S-222	2115	COMINT
Wilson	EC	Bu-203	2838	EW, radar, and ELINT

VII. ADVISING PROCEDURES

A. General

Counseling on and approval of your academic program is the responsibility of your Curriculum Office and your Academic Associate. Your Academic Associate is responsible for the academic integrity of your program and will be available for assistance during posted office hours. Your records will be kept in the Curriculum Office. Most of you will want to make changes to your program at some time. When you come to discuss major changes, please bring your course matrix and any other appropriate information. It is extremely difficult for your Academic Associate to remember the fine details of your individual programs without the aid of your matrix. Also, do not hesitate to stop in to discuss potential problems. It is better to address them while they are still solvable!

B. Pre-Registration and Scheduling

Once your program has been worked out and tentatively approved by your Academic Associate, it should be taken to the Curriculum Office and submitted for entry into PYTHON. Every attempt will be

made to schedule all students for all courses requested, without conflict. It is important to remember that if you wish to make changes in your program, they should be made as soon as possible, even if they are several quarters in the future. Otherwise, scheduling conflicts may occur or courses may be cancelled due to low enrollment. The minimum number of students varies from department to department, but typically ranges from 6 to 8. Also, do not enroll in courses in which you do not intend to remain. Faculty members have the responsibility to not sign and Add/Drop if it will adversely affect the class enrollment (i.e., increase the size to an unmanageable level or drop the class down to a low level).

C. Adding or Dropping Courses

If you want to add a class for which you have not been pre-enrolled or to drop a class for which you have been pre-enrolled, it is necessary to complete the DROP/ADD procedures in PYTHON. Approval will be required from your Academic Associate. It is not necessary to obtain the instructor's approval to drop a course in the first two weeks. However, it is always necessary to obtain the instructor's permission to add a course. Some courses are limited as to the number of students that can be accommodated. **Be aware of the Python deadlines.**

NAVAL POSTGRADUATE SCHOOL
Monterey, California

INFORMATION SCIENCES DEPARTMENT

Checklist for MSSE Degree

Student Name: _____

Month and Year Enrolled: _____

1. List all graduate courses taken:

<u>3000 Courses</u>	<u>Credits</u>	<u>4000 Courses</u>	<u>Credits</u>
---------------------	----------------	---------------------	----------------

2. Total graduate hours (45 minimum): _____ (Note: Courses for degree credit are limited to engineering, science, mathematics, computer science, physics or operations research unless approved by the Academic Associate.)

3. Total 4000 hours (15 minimum): _____

4. Academic disciplines (4 minimum): _____

5. 4000 level academic disciplines (2 minimum): _____

6. Approved sequence of three courses constituting advanced study in an area of specialization:

7. Thesis:

Title: _____

Advisor: _____

I certify that the information provided on this Degree Checklist form is correct:

Student

Academic Associate

Curriculum Officer

Chairman, IW Academic Group

INFORMATION WARFARE ACADEMIC GROUP

Thesis Proposal Approval Form

Name _____ SMC _____ Home Phone _____

A. Curriculum: _____

B. Date of Graduation: _____

C. Degree: _____

D. Tentative Thesis Title: _____

E. Thesis Advisor: _____

F. Second Reader: _____

G. Anticipated Funding Requirements (if any): _____

Funding Provided by: _____

H. Classification: _____

Please answer items 'I' through 'N' on separate sheets. Descriptions of these items follow.

Approved/Disapproved Advisor: _____ Date: _____

Approved/Disapproved 2nd Reader: _____ Date: _____

Approved/Disapproved Acad. Assoc.: _____ Date: _____

Noted: Curric. Officer: _____ Date: _____

Approved/Disapproved Chairman: _____ Date: _____

I. Research Questions

Identify the primary research question and subsidiary research questions. The primary research questions should be broad enough that it covers the entire spectrum of the research activity. Subsidiary research questions subdivide the primary research question into manageable research segments. This should be a very explicit statement of the questions the research will seek to answer. While the questions may be redefined later as the research progresses, the initial objective should be made very specific.

J. Discussion of Topic

Describe the main thrust of the study, what areas will be specifically investigated and what areas will be excluded; put boundaries around the study; identify what the study will be (e.g., a computer simulation, an experiment, an electronic design and implementation, a system study); discuss any limitations of the study.

K. Tentative Chapter Outline

Identify tentative chapter headings and provide brief discussion of chapter content (*Note: This can change*).

L. Benefit of Study

State of the contribution expected from your research efforts, what individuals or organizations will use the results of your thesis, and what problems/issues you feel will be addressed/resolved.

M. Preliminary Bibliography

Provide a listing of representative materials consulted during preliminary literature search. This should include references to the problem or issue to be studied, prior thesis work, literature references, or other sources of information. The final bibliography will probably be much more extensive.

N. Milestones

This is a tentative list of target dates for completion of the successive stages of the project. You will not be held strictly to this schedule; it is a means of conveying to others when you expect to complete major milestones of the study. Give the dates during which the following activities will be accomplished:

1. Literature review
2. Construct research/approach
3. Conduct research/travel
4. Analyze data
5. Draft thesis
6. Final thesis submission/signature